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HYBRID FRACTAL IMAGE COMPRESSION BASED ON RANGE BLOCK SIZE

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Abstract
The present paper proposes Hybrid Fractal image compressions (HFIC) for grey and Color images. The HFIC method is carried out for the variable size range blocks. The sample images here are divided into blocks by considering minimum and max size ranges. This method transforms the RGB color image into three planes and then divide them into variable ranges. To achieve fractal compression, Relative transformation and entropy coding is applied. The image is reconstructed by applying the inverse transforms and iterative functions. The results of the present analysis demonstrate that, for the hybrid fractal compression scheme with variable range method applied to color and gray scale images like Lena, medical MRI etc, show higher CR and PSNR values compared to fixed range block size and other existing methods. The results indicate that both color and gray level images with R_{max} = 16 and R_{min} = 8 shows higher Compression ratio(CR) and good Peak Signal to Noise Ratios (PSNR).

Keywords: *Hybrid fractal image compression (HFIC), Minimum range Block, maximum range Block, Relative transformation and entropy.*

Nomenclature

HFIC	Hybrid Fractal Image Compression
MRI	Magnetic Resonance Imaging
FIC	Fractal Image Compression
PSNR	Peak Signal to Noise Ratio
CR	Compression Ratio
MFCSA	Modified Fractal Coding on Spiral Architecture
GA	Genetic Algorithm
D-Block	Domain Block
R-Block	Range Block

1. Introduction
A fractal can be defined as a geometrical shape that is self-similar i.e. it has parts that is similar to the whole. Fractal-based image compression (FIC) techniques exploit redundancy due to self-similarity properties in images to achieve compression [1]. Fractal image compression schemes for image compression have been developed and implemented.

Generally, Image compression means minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level [1]. The main motto of reduction in file size is more images to be stored in a given amount of disk. Another advantage is reduces the time required to upload and download the images over an internet. The main principle of the image compression is that the neighboring pixels are correlated and therefore contain redundant information. The foremost take of the Image Compression is to find the correlated representation of the image[2].

The idea of Fractal Image Compression (FIC) was originally introduced by M.F.Barnsley and S.Demko [3]. Fractal image compression that uses the characteristics of existing self similarity [4, 5] within images is a suitable method for coding an image. Jacquin introduced fractal image encoding based on PIFS [6] later. Fractal Image Compression (FIC) is the most widely used applications such as image retrieval, texture segmentation, feature extraction and image signature in the field of image processing [7].Fractal compression allows fast decompression but has long encoding times. The most time consuming part is the domain blocks searching from each range [8, 9].

2. Literature Review
From the past few years, so many fractal image compressions techniques are proposed by many researches and authors. In fractal image compression, the image is separated into various domain blocks with subjective size ranging from 4×4 to 16×16, or more. At that point, the picture is divided again into range blocks of short size than that of the block domain [10]. For each domain range match two transformations are required, a geometric change which maps the domain to the extent and an relative transformation that modifies the intensity values in the domain to those in the extent [11]. The fractal compression technique as explained in [12], [13], [14] is basically a search process consists of partitioning the image into sub images and search for parts of the images which are self similar. The various partitioning schemes are compared in [15]. The algorithm used for encoding is the Partitioned Iterated Function System [16] compared

with other image compression methods, hybrid fractal with binary plane algorithm [17].

M.Ismail *et al* [18] proposed a fractal image compression system focused using range size. Rama Krishna et.al [19] executed lossless compression using Huffman coding working straightforward with quantized coefficients. D.Venkatasekhar et.al [20] proposed FIC method for image compression based on Polynomial hybrid Wavelet and particle Swarm optimization. This method use DCT and DWT techniques but it takes most computing time for domain blocs. The method is applied on only three categories of images such as parrot, car and flower. When this method is applied on other categories of images good and comparative results are not obtained.

Wei Hua Rui et al., proposed a progressive texture compression framework [21] to reduce the memory and bandwidth cost by compressing repeated content within and among large-scale remote sensing images. M. Ashok. T. Bhaskara Reddy et al proposed, Color Image Compression based on Luminance and Chrominance[22] Nileshsingh V. Thakur, Dr. O. G. Kakde [23] proposed the approach Modified Fractal Coding Algorithm for Grey Level Images on Spiral Architecture (MFCSA), composing with the one-plane image using the pixel's trichromatic coefficients. One-plane image in traditional square structure is represented in Spiral Architecture for compression. On this Spiral Architecture image, proposed modified Fractal grey level image coding algorithm (MFCSA) is applied to get encoded image.

The research has been carried out to achieve the fast speed of fractal encoding and also high quality of reconstructed image [24, 25, 26, 27, 28]. From the above literature observed that no single method is applied for all categories of images.

A.R. Nadira Banu Kamal et.al [29] proposed an efficient search of the domain pools for color image compression using Genetic Algorithm (GA). The proposed method reduces the coding process time and intensive computation tasks. Image quality factor, compression ratio and coding time are analyzed in this approach and comparative results are obtained but this method is also suitable for only limited categories like facial, building and vegetable images. K. Raja Kumari et.al [30] proposed a fractal image compression technique based discrete wavelet transform is followed by Huffman Run length Encoding. This method is mainly focused on improving the image quality after compression. This method is also not suitable for all categories.. Bakul Pandhre et.al; [31] proposed an approach to reduce the encoding time of an image by classifying the blocks according to an approximation error measure. This method is also applicable not applicable for many categories of images.

From the above literature survey we observed that no such method is available to compress the all categories of images by using FIC technique with good image quality after compression. This problem is addressed here and a method is developed called Hybrid Fractal image compression (HFIC) to compress major categories of images like standard pepper , lena medical MRI ,Internet images etc.

The paper is organized into the following sections. Section 3 describes the preliminaries of basic fractal image encoding and decoding approach and section 4 emphasizes on the Hybrid Fractal image compression. Results and discussion are focused in section 5 and conclusions are given in section 6.

3. Fractal image encoding and decoding process

The essential steps of fractal image compression (FIC) are as follows

Step 1: Partition original image into non-overlapped little sub windows. Each sub window is called Range-R block

Step 2: For each R-block, discover an overlapping image block i.e. Domain block or basically called D block. The D block which is most similar to current R-block under a certain change

For example, if the size of the image is 256×256 which is to be encoded having 256 gray shades. If the size of the R-block is considered as 8×8 then the available R-blocks in a entire image is 1024. These entire R-blocks are composite into R-pool. Suppose D-block is four times larger as R-block viewed then the quantity of accessible D-blocks is $(256\text{-}2{*}8{+}1)^2$=58081 and all these D-blocks are composite D-pool.

Step 3: For every R-block, locate suitable D-block from the D-pool which is most parallel to it.

The concrete steps for discovering the suitable D-block from D-pool which is most parallel to corresponding R-block are

(i)Crop the D-block size to the size of R-block by Shrink operation and, marked the D-block as D'-block using Four neighborhood regional method shrink operation.

(ii)Swap the D'-block by using eight relative transformations matrices which proposed by Jacquin. Shown in figure 1.

$T_0 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$	$T_1 = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$	$T_2 = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix}$	$T_3 = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$
$T_4 = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix}$	$T_5 = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$	$T_6 = \begin{pmatrix} 0 & -1 \\ -1 & 0 \end{pmatrix}$	$T_7 = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$

Figure 1. Relative Transformations Matrices

(iii)Eight relative transformation blocks are generated for each D'-block and these blocks now composite new D-pool.

(iv)Match up to each R-block with the blocks which are in D'-pool and obtain nearly all similar blocks. The matching can be measured with normal clash MSE. Generally the R-block and D-block are vectors thus, the MSE can be measured by using the following equation 1.

$$MSE = //(X_k \;*D_{k,} + Y_k \;*1 - R_k\;)// \qquad (1)$$

Where X and Y are the coefficients and should have the following values for making the MSE values minimum. The coefficients are considering form well known least square method. The X_k and Y_k are represented in the equations 2 and 3 respectively.

$$X_K = \frac{B^2 \langle D_{k,} R_k \rangle - \langle D_k, I \rangle \langle R_k, I \rangle}{B^2 \langle D_k, D_k \rangle - \langle D_k, I \rangle^2} \qquad (2)$$

$$Y_k = \frac{<R_k, I> - <D_k, I>}{B^2} \tag{3}$$

The meaning of the above step is choosing a block with the smallest approximation of D-block's eight transformations matrices for R-block with least square approximation. Then compression relative transformation W. *W = {Dk(x,y), Tk, Xk, Yk)*.of each R-block is expressed in the equation 4 Where $D_k(x,y)$ represents the D'-block's staring position and T_k represents the corresponding relative transformation matrix.

(v)Store up the compression relative transformation W for each R-block. All clamping relative changes constitute the entire image's fractal code.

The figure 2 represents the schematic diagram of the conventional fractal encoding process when applied on Lena image.

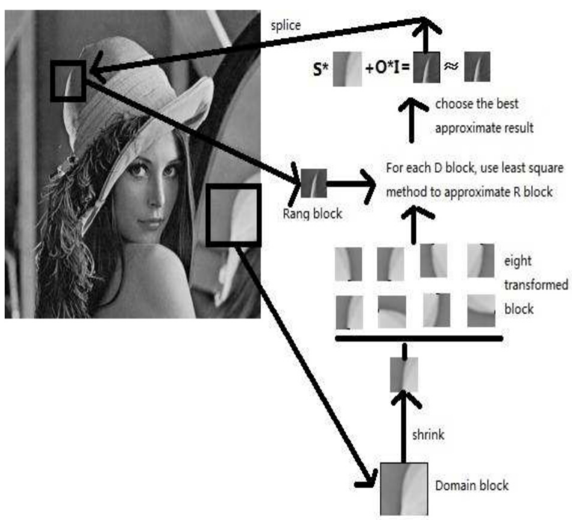


Figure 2: Schematic diagram of the fractal encoding process

3.1 Fractal image decoding process

The fractal decoding procedure is quite simple, that is, for all R blocks, act the corresponding relative transformation on any one initial image, iterate for several times(commonly ten times) , according to fixed point theorem, this iteration process would converge to a fixed attractor, and this attractor is the decoding image.

Adaptive threshold quad tree fractal compression approach is the same as the basic fractal image encoding method, the main difference is, when doing image match, we don't find the global best-match block in D-pool, and instead, we use an adaptive threshold to judge whether the current R-block matches D-block, if the two's match error MSE is smaller than threshold, we can consider that current D-block matches R-block, otherwise, the two are not matching. The threshold is proportional to the image block's variance. When block's variance is larger, i.e., block has a high complexity, and has much high-frequency signal, we can allow a greater distortion in recovery image block. When block's variance is smaller, i.e., block has a low complexity, and has much low-frequency signal, we must limit the distortion to a certain level.

Points observed from FIC approach

(i) Fractal image compression approaches do not consider the picture's content.

(ii) FIC divides image into regular square image sub block. This effects visually recovered image when the main image block is larger in size, reducing SNR. But when image block has a smaller size, it can increase D-blocks' count, thus increasing the encoding time and reducing compression ratio. Inspired by this, it is proposed to use some statistic information of image block (such as gray average, variance, fractal dimension) to speed the matching process reducing time complexity.

From the above discussion, it is clear that in fractal image compression, the encoding time and intricacy is high furthermore distinctive techniques are utilized for different images. To overcome these issues, an efficient hybrid scheme focused around variable range block with quadrant methodology is proposed for encoding.

4. Proposed Hybrid Approach

The main objective of proposed work is to increase the effectiveness of encoding and decoding process in FIC and also compress the RGB images instead of grey level images. The proposed hybrid algorithm enhances the fractal image coding and attempts to improve and increase the compression ratio while maintaining a high reconstructed image quality.

FIC is basically dividing the original image into non-overlapping regions called R blocks and overlapping regions called D blocks. For each R block, the greatest matching D block must be found by relative changes W_i is of the form as follows in equation (4).

$$W_i \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a_i & b_i & 0 \\ c_i & d_i & 0 \\ 0 & 0 & S_i \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{bmatrix} c_i \\ f_i \\ o_i \end{bmatrix} \tag{4}$$

In above relative changes w_i, s_i manages the contrast and o_i controls the brightness and a_i, b_i, c_i, d_i, e_i, f_i means the eight symmetries like for example, identity, rotation through +90º, rotation through +180º, rotation through -90º,reflection about mid-vertical axis, reflection about mid-horizontal axis, reflection about first diagonal and reflection about second diagonal. Figure 3. shows the proposed hybrid fractal image compression system for color images and proposed algorithm is shown below

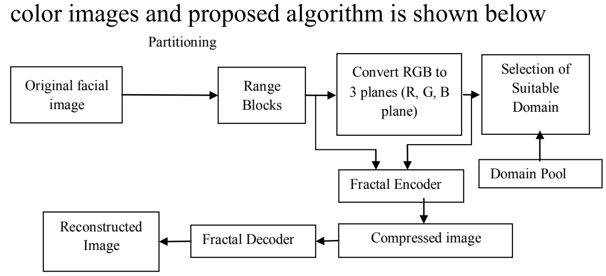


Figure 3: The Schematic diagram of the Proposed Method

4.1 The Hybrid Fractal Encoding and Decoding Algorithm:

The algorithm steps are as follows

(i)Separate R, G, and B components of an image. The image is converted to three 2-D matrices i.e. Red plane image, Green plane image and Blue plane image.

(ii)Each plane image will be partitioned into non-overlapping blocks. These are called Range block or simply R-block. Initially select the R-block size ranges. The maximum Range block of size (R_{max}) is 16 or 8 and minimum Range block of size (R_{min}) is 4 or 8. R-blocks are compared with domains from the domain pool, which are twice the range size.
(iii)The domain block with the size of window K×K are sliding over the entire 3 separated images in steps of K/2 or K/4 known as lattice. The pixels in the domain are averaged in groups so that the domain is reduced to the size of the range and applying relative transformation.
(iv)After partitioning and transformation, the fractal encoding process is the search of suitable candidate from all available blocks to encode any particular range block.
(v)Attempts to improve encoding speed involves classification of sub-image into upper right, upper left, lower right and lower left quadrants shown in Figure.4. On each quadrant compute values proportional to the average intensities of the 3 plane images. They will follow one of the three ways as canonical ordering .

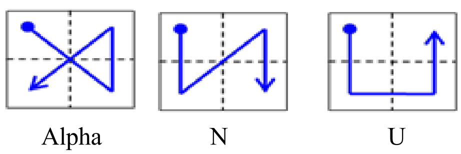


Figure 4: Classification Scheme of the Sub Image by Canonical Ordering

They are (a) Major Class 1: $v_1>v_4>v_2>v_3$
(b) Major Class 2: $v_1>v_3>v_2>v_4$
(c) Major Class 3: $v_1>v_3>v_4>v_2$

(vi)Addition to the above three major classes, there are 24 different subclasses for each major class. So totally domain and range blocks are represented in 72 classes. In coding process any range block is mapped to the domain blocks and using of the entropy coding to achieve fractal compression for each plane image
(vii) Record the fractal decoder to re-construct the image and calculate CR and PSNR.

5. Results and Discussions

To find the effectiveness of the proposed method illustrated by means of the experimental results. The proposed approach was executed in Matlab 13b on Intel core i3 processor with 2 GB RAM and the proposed method was evaluated on both gray and color images. The Proposed technique is applied on a set of color images of different categories with the standard size512×512. The test images used in the experiments are the color Standard Lena image of size 512×512, Medical images with the resolution of 512×512 is obtained from Hospital, Pepper image with size of 512×512, Zelda image from goggle with the size of 512×512 and God hills images form Google with the size of 600×800. In our experiment all images consider the standard size 512×512. The Quality of the re-constructed images was determined by measuring the Peak Signal to Noise Ratio (PSNR) value and the Compression Ratio(CR) for both color and grey level images.
By using the variable range block size for three cases namely (a) R_{max}= 16 and R_{min} = 4 (b) R_{max} = 16 and R_{min} = 8 (c) R_{max} = 8 and R_{min} = 4, the imageries are subjected to proposed hybrid fractal image compression (HFIC) scheme. The Compression Ratio (CR) and Peak Signal to Noise Ratio (PSNR) values for the both color and gray images of Standard Lena, Medical MRI , pepper ,god hills & Zelda are determined and obtained results are tabulated in Table 1 and 2 respectively. The uniqueness of the proposed method is, it gives good comparable results when applied on both color and grey imageries
The computational cost of the proposed method on Intel core i3 processor with 2 GB RAM is about 90 seconds for standard color image of Lena with size of 512×512.Compression Time for the God hills image with size 600×800 is 101 seconds. When applied to compress the Medical images with size 512×512 time taken is about 79 seconds. For compressing Zelda images with size 512×512 the proposed algorithm takes about 79 seconds.
It is observed from the table 1 that out of the three variable range methods, size R_{max}=16 and R_{min}=8 show better performance in CR and R_{max}=8 and R_{min}=4 show better PSNR for test colour images. Further Table 2 indicates comparable performance in the CR and PSNR values for test grey images.

Table.1: CR and PSNR of Test Color Images

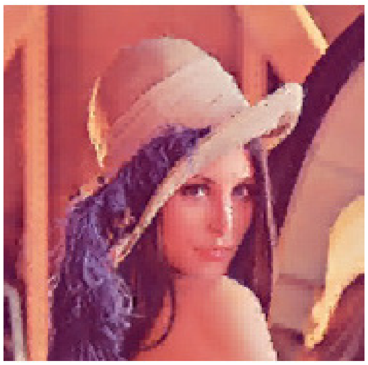
S. NO	Test Images	R_{max}=16 and R_{min}= 4		R_{max} =16 and R_{min}=8		R_{max} 8 and R_{mi} =4	
		C.R	PS NR	C.R	PSNR	C.R	PSN R
1	Lena Image	3.09	27.63	17.85	24.95	3.27	32.5 6
2	God Hills Image	3.96	19.75	16.75	20.57	3.18	31.2 5
3	Pepper Image	3.84	20.75	18.95	21.26	3.28	30.2 5
4	Medica l Image	3.56	21.25	17.38	22.49	3.09	31.2 3
5	Zelda image	3.78	19.57	18.83	23.54	3.12	29.9 6

Table.2: CR and PSNR of Test Gray Images

S no	Test Images	R_{max}=16 and R_{min}= 4		R_{max} =16 and R_{min}=8		R_{max} 8 and R_{mi} = 4	
		C.R	PS NR	C.R	PS NR	C.R	PSNR
1	Lena Image	3.01	28.85	17.54	25.58	3.04	31.15
2	God Hills Image	3.19	22.54	18.75	24.36	3.37	31.29
3	Pepper Image	3.35	21.52	19.75	23.49	3.59	30.26
4	Medica l Image	3.89	23.16	17.23	22.51	3.42	32.81
5	Zelda image	3.64	20.19	18.75	23.49	3.19	31.56

The original and reconstructed color test images for the variable range block size R_{max}=16 and R_{min}= 8 are shown in Figure.4 to 8. It may be seen from the figures that the using variable range size for all different category images significantly good quality of reconstructed images is maintained .Similarly the results of the grey level images are shown in Figure. 9 to 13.

(a)



(b)

Figure .4: Results of Lena color image a) Lena Image b) re-constructed Lena image

(a)

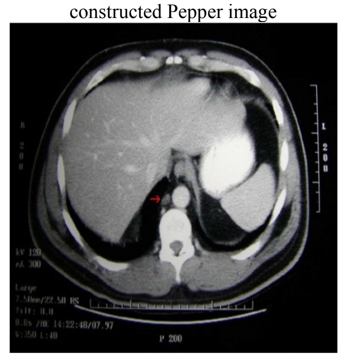
(b)

Figure 5: Results of God Hills color image a) original God Hills b) re-constructed God Hills image

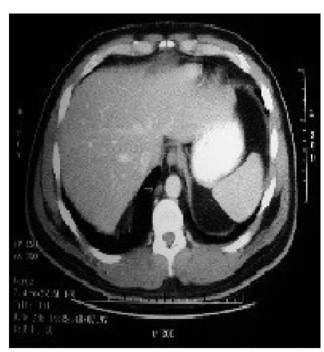
(a)

(b)

Figure 6: Results of Pepper color image a) original Pepper image b) re-constructed Pepper image



(a)



(b)

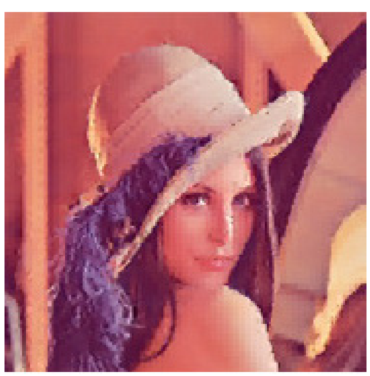
Figure. 7: Results of Medical MRI color image a) original Medical MRI image b) re-constructed Medical MRI image

(a)

(b)

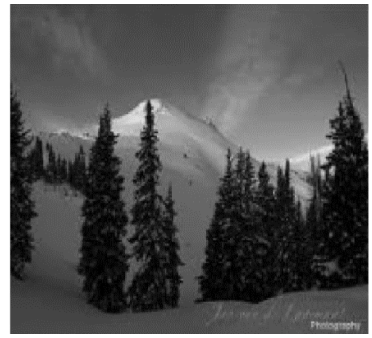
Figure.8: Results of Zelda color image a) original Zelda b) re-constructed zelda image

(a)



(b)

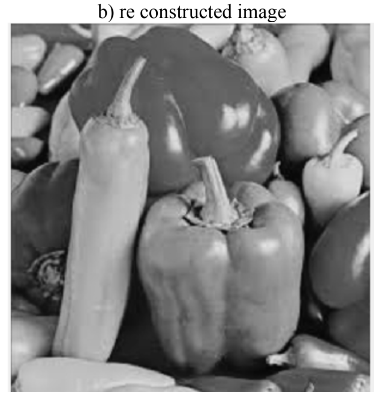
Figure. 9: Results of Lena gray image a) original lena gray Image b) re constructed lena image



(a)

(b)

Figure. 10: Results of God hills image a) original gray God hills Image b) re constructed image



(a)

(b)

Fig. 11: Results of pepper gray image a) original gray pepper Image b) re constructed pepper image

(a)

(b)

Figure. 12: Results of Medical MRI grey image a) original Medical MRI image b) re-constructed Medical MRI image

(a)

(b)

Fig.13: Results of Zelda gray image a) original gray zedla Image b) re constructed Zelda image

5.1 Comparison with other Existing Methods

The proposed Hybrid Fractal Image Compression (HFIC) method obtained values for CR &PSNR are compared with the other existing methods like standard algorithm of quad tree technique[32], fractal with quad tree & Discrete Cosine Transform technique[33], and Fractal image compressions based on variable size range block[34] in Table 3 ,4 and Table 5,6 for color & grey images.

The CR and PSNR values obtained from the proposed method in both color and gray level image for variable range block size R_{max}=16and R_{min}= 8 are comparatively better as depicted in figures 14,15, 16.

Table 3: CR of the proposed method and other available methods of color images

SNO	Test Images	Standard algorithm of Quadtree Technique (SAQT)	Fractal with Quadtree and DST Technique(FQ&DST)	FIC based on variable size range block method (FIC VRB)	Proposed HFIC
1	Lena Image	10.35	14.03	13.9	17.85
2	Pepper Image	9.75	13.75	14.5	15.63
3	Zelda Image	9.63	14.06	15.75	15.48
4	God Hills Image	9.98	13.86	15.25	16.75
5	MRI Image	10.25	13.94	14.96	17.53

Table 4: CR of the proposed method and other available methods of gray level images

S,No	Test Images	Standard Algorithm of Quadtree Technique(SAQT)	Fractal with Quadtree and DST Technique(FQ&DST)	FIC based on variable size range block method(FIC VRB)	Proposed HFIC
1	Lena Image	9.72	12.32	13.6	17.54
2	Pepper Image	8.86	12.45	16.52	18.75
3	Zelda Image	9.1	13.24	17.32	19.23
4	God Hills Image	8.96	12.68	16.46	19.64
5	MRI Image	9.12	12.73	17.54	18.94

Table 5: PSNR of the proposed method and other available methods of color images

S,No	Test Images	Standard Algorithm of Quadtree Technique (SAQT)	Fractal with Quadtree and DST Technique	FIC based on variable size range block method(FIC	Proposed HFIC
1	Lena Image	25.64	30.83	25.9	32.56
2	Pepper Image	23.46	29.63	19.75	32.56
3	Zelda Image	22.15	30.25	18.64	33.54
4	God Hills Image	24.15	31.64	16.75	34.56
5	MRI Image	24.65	30.49	17.46	32.49

Table 6: PSNR of the proposed method and other available methods of gray level images

S,No	Test Images	Standard Algorithm of Quadtree Technique(SAQT)	Fractal with Quadtree and DST Technique (FQ&DST)	FIC based on variable size range block method(FIC VRB)	Proposed HFIC
1	Lena Image	24.86	30.18	26.5	31.15
2	Pepper Image	2.75	30.15	17.65	31.56
3	Zelda Image	23.65	29.45	18.56	33.57
4	God Hills Image	24.51	27.56	19.43	34.56
5	MRI Image	23.49	28.64	19.54	33.72

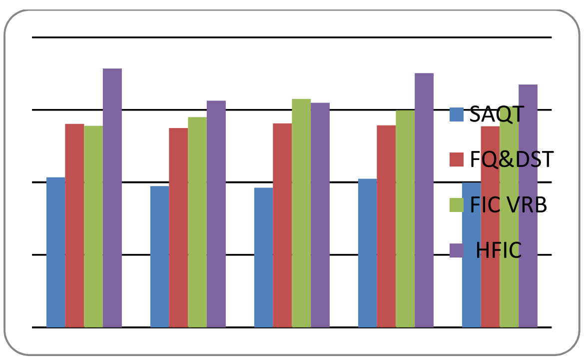


Figure 14: Comparison chart of CR of the proposed method with other existing methods when applied on color test images

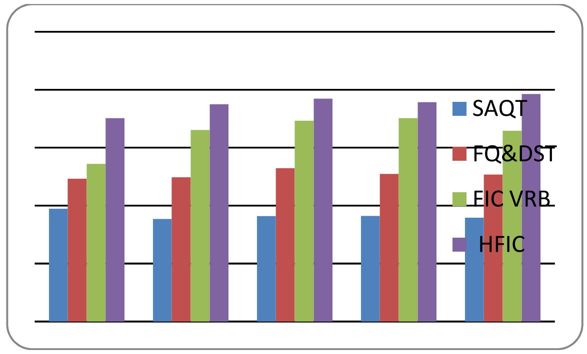


Figure 15: Comparison chart of CR of the proposed method with other existing methods when applied on grey test images

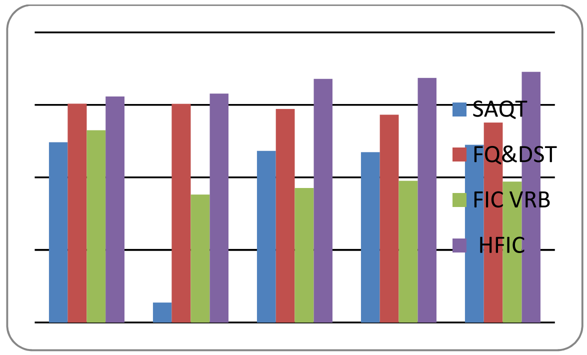


Figure 16: Comparison chart of PSNR of the proposed method with other existing methods when applied on color test images

6. Conclusions & Future scope

In this paper, experimental work is done to generate hybrid fractal image compression using variable range block size. The experimental results demonstrate that the variable range block size of R_{max}=16 and R_{min}=8 gives better results compare to range blocks. It is clear that the proposed method obtains best image quality with low computational cost for both color and grey level images giving approximately same CR and PSNR values. When compare with the fixed block size method of fractal compression schemes, the present method exhibits higher compression ratio and PSNR values for all types of imageries. The proposed method is tested for different categories of images like standard color images, natural image, God Hill images, pepper image, MRI images and Zelda images gives comparatively good results. The PSNR values obtained in this approach is always greater than 30. The average computational cost of the proposed method for all categories of images is about 123 seconds.

Further the proposed method image metrics can be improved when combined with certain lossless compression techniques where in machine learning algorithms can be used for further improving computational time

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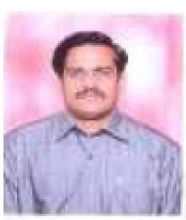

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